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NOTES AND LITERATURE

PROTOZOA

Doflein's "Lehrbuch der Protozoenkunde."¹—No group of animals affords a more direct approach to the problems of evolution than the Protozoa and few offer such varied data for their discussion. The organism and the individual are here reduced to lowest terms and the processes of growth, differentiation, degeneration, regeneration and reproduction in the most varied forms are found in astonishing variety and complexity. The phenomena of overcrowding, rapid destruction, parasites and parasitism, immunity, variation, speciation, isolation and perhaps even mutation, with all of their consequences on structure and reproduction, are illustrated in varying degrees of diversity and completeness. It is therefore to be expected that a thoroughgoing review of the rapidly augmented literature of protozoology by Professor Doflein will yield some new points of view or at least a new perspective in which old conclusions and hypotheses may be tested.

The biogenetic law, for example, in the opinion of the author of the "Lehrbuch" is very doubtfully applicable to the Protozoa. External factors profoundly affect the form and structure of these simple organisms. Increased alkalinity of the water changes *Amæba limax* to *A. radiosa*, as Verworn has shown. Trypanosomes vary greatly in appearance and virulence, according to the hosts in which they are cultivated, and in culture media locomotor organs are lost and nucleus and blepharoplast are shifted into new relations in the cytoplasm. Reproductive processes are profoundly modified by temperature and chemical media. The kind of food, according to Faure-Fremiet, affects the structure of *Vorticella*. The form changes, therefore, through which a protozoan runs in its life cycle are to be regarded as moulded by external influence rather than by internal factors of heredity and the production of similar structures is a phenomenon of convergence rather than a proof of relationship or descent.

This point of view determines Doflein's treatment of certain important questions. Thus the Suctoria form a class coordinate

¹"Lehrbuch der Protozoenkunde." Eine Darstellung der Naturgeschichte der Protozoen mit besonderer Berücksichtigung der parasitischen und pathogenen Formen. Zweite Auflage der "Protozoen als Parasiten und Krankheitserreger." Von Dr. F. Doflein. Pp. x + 914. Mit 825 Abbildungen im Text. Jena, Gustav Fischer, 1909. M. 24. Geb. 26.50.

with the Ciliata since the posterior circlet of cilia formed on the bud of *Acineteta* is a convergence phenomenon attendant upon the free-swimming life of this stage rather than primarily an ancestral character indicating the derivation of the Suctoria from the Ciliata.

Again the occurrence of flagellate-like stages in the life history of the *Plasmodium*, *Babesia* and *Leishmania* is not regarded as of phylogenetic significance but as an independently derived adaptive stage. The Hæmosporidia are therefore not transferred from the Sporozoa to the Flagellata by Doflein as Hartmann and others have argued. On the other hand, the trypanosomes are regarded as having been derived from parasites of insects such as *Herpetomonas* and *Crithidia*, whose forms they resemble in culture media.

Doflein is skeptical about the specific distinctness of the various pathogenic trypanosomes of mammals, though recognizing the necessity of distinguishing them to avoid confusion, by their hosts, occurrence and typical form in the blood of the host. They are forms merely, not fixed species, and doubtfully even incipient species. He holds as uncertain even the specific distinctions in the so-called gametes of *T. gambiense* and *T. brucei* in the tsetse fly reported by Koch. He also rejects as hypothetical the sexual cycle of *T. lewisi* in the rat louse reported by Prowazek, regarding the evidence as based on abnormal stages altogether too rare in occurrence to be typical sexual phases. However the more recent work of Minchin, Baldry and Breinl and Hindle tends to confirm the view that a sexual phase of the parasite may occur in the insect host.

The Protozoa are regarded as a group whose limits are arbitrarily defined in the interests of economy in scientific work rather than by structure. No sharp boundary line separates then on the one hand, from the Metazoa—witness the spore of *Nosema* or that of the *Actinomyxidina*—or, on the other, from the lower Metaphyta, as may be seen in the family Volvocidæ within which numerous types of colonial organization have been evolved. Not only do the Protozoa intergrade with Metazoa, the lower algæ, moulds and fungi in morphological characters, but also in physiological as well.

The author has for some years consistently maintained that the lowest branch of the Protozoa is not the Rhizopoda as stated in practically all text-books and manuals, but rather that the Mastigophora are to be regarded as lowest in the scale of organization. This is based not only upon the occurrence of flagellated forms in the gametes or other reproductive phases in the life history of

other classes, but also upon the relationships of the Mastigophora to the Bacteria. This relationship is traced by Doflein through the Spirochaetes which he names also Proflagellata, to *Spirillum* and like forms. The suggestion is made that the Bacteria are the equivalents of postulated Monera of Haeckel, though they are far from resembling the forms actually described by him as Monera, and that bacteria other than *Spirillum* should be in like manner attached to other groups of protists to which they may be related. Attention is called to the wide-spread occurrence among Protists of chromidial cells, that is those seemingly without nucleus but having finely divided and distributed chromatin as seen in Bacteria, *Oscillaria*, *Nostoc* and *Tetramitus* and to the appearance of this same type of distribution of chromatin throughout the cell body among Protozoa at certain stages of life history, especially in gametogenesis, though also in hunger-stages and in pathological conditions. He wisely sounds a note of warning against the domination in protozoology of the morphological conception based upon the Metazoan cell, and a note of caution against the possible interpretation of minute parasites as chromidia. Ingested chromatin, as Martin has shown in the Suctoria, also offers a pitfall for the chromidia hunter.

The theory of Schaudinn and Goldschmidt of the fundamental dualism of the nuclear substance in the Protozoa, of the existence side by side in the cell of sexual chromatin as exemplified in the micronucleus of *Paramecium*, of the generative chromidia of the Foraminifera, and the nuclear membrane substance of *Acanthometra* and of somatic chromatin as seen in the macronucleus of the ciliates, he regards as only a convenient morphological schema not justified by either the comparative morphology or the physiology of the Protozoa as a whole. He inclines rather to Hertwig's view of the unity of the chromatin substance.

Dr. Doflein acknowledges the great service which the theory of Hertwig regarding the proportions of nucleus and cytoplasm has rendered to science in the stimulation of research, but looks to the future to assess its permanent value. He suggests that depression stages resulting, on the one hand, in the regulating processes of sexual reproduction or, on the other, in degeneration and natural death, are exceptional "in der freien Natur." To the reviewer the astounding fluctuations¹ in numbers which the organisms of the fresh-water plankton undergo in short periods of time of three to five weeks, rising from minimum numbers to

¹ Kofoid, C. A., 1908, "Plankton of the Illinois River," Pt. II, Constituent Organisms and their Seasonal Distribution, *Bull. Ill. State Lab. Nat. Hist.*, V. 8.

maximum of extreme proportions and falling away again with equal or greater abruptness with accompanying high death rate and appearance of sexual reproduction, especially in rotifers, seem to be of a similar nature to the cycles with intervening depression periods in laboratory cultures. These occur, moreover, constantly and with surprising regularity in nature, in both marine and fresh-water plankton among organisms of short life-cycles.

Certain points in both Schaudinn's and Hertwig's theories of sexual reproduction are combined with the earlier suggestions of Bütschli in a theory of sex which has much in common with that put forth by Geddes and Thomson. Living cells are conceived as consisting of two groups of substance, one more fluid in consistency concerned with the dynamic activities such as cell division and locomotion, the other more solid, the reserve stuff for the activities of life. In cell division these substances are not equally distributed, reserve stuff predominates in some (females) and the locomotor substance in others (males). Morphological cell constituents for these substances are expressly not postulated. An indifferent protozoan by division gives rise to equal numbers of differentiated male and female individuals, whose differentiation increases as division progresses. Fertilization takes place in consequence of the physico-chemical attraction of the two substances. The same chemical differences which condition the form-distinctions of the gametes are also the prime cause of the union in fertilization.

This theory naturally is easily applicable to the indifferent, male and female forms of Trypanosomes and to the highly differentiated sexual process and gametes of the Sporozoa generally, but requires further elucidation to make it applicable to isogamy, which is perhaps the primitive type of sexual reproduction and one seemingly widespread among Protozoa.

Dr. Doflein's book is not only a great mine of carefully and critically assembled information on Protozoa, but his facts are marshaled with reference to the great problems underlying all biological work in such a way as to stimulate further research.

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CELEBRATING DARWIN'S GREATNESS AND DARWINISM'S WEAKNESS

It will seem less ungracious now that the year has turned, the one-hundredth year since Darwin's birth and the fiftieth